MONITORING CIRCUIT

TECHNICAL FIELD OF THE INVENTION

This invention relates to a monitoring circuit, and in particular to a circuit for monitoring a battery voltage, for example in a mobile communications device such as a mobile phone.

BACKGROUND OF THE INVENTION

In operation of a battery-powered mobile communications device, such as a mobile phone, it is useful for a controller of the device to have information about various system parameters, such as the voltage being supplied by the battery. However, if frequent measurements are made by the controller, this requires a large number of measurements to be sent over the internal communication bus of the device, which puts an increased load on the controller, and results in higher power consumption.

US-5,570,025 describes a cellular phone in which, during a call, battery voltage measurements are sent to a CPU for processing.

JP-11-183532 discloses a battery monitoring apparatus with an analog-digital (A/D) converter, which converts a measured battery voltage into a digital signal, and monitors the signal in cycles. The device further includes means for setting a reference voltage, and for comparing the digitized battery voltage with the reference voltage, providing an output interruption signal to the processor when the voltage drops below the reference voltage. Thus, battery monitoring is carried out independently of the processor, until the voltage falls below the preset reference voltage.

Although this system provides a warning when a battery voltage falls below a preset threshold, it does not provide any further information about the condition

of the battery.

SUMMARY OF THE INVENTION

In accordance with one aspect of the invention, a monitoring device includes output registers, from which parameter values can be read by a processor unit.

Advantageously, the device makes frequent measurements, and updates parameter values on the basis of those measurements. The updated stored parameter values can then be read by the processor.

This has the advantage that the processor does not have to read a large number of values, in order to obtain the information required about the parameters. This therefore has the result that communications on the bus are reduced, and power consumption is reduced.

For example, the parameters may include a maximum battery voltage, a minimum battery voltage, and an average battery voltage.

Moreover, the monitoring device can be used as a battery monitor in a mobile communications device, such as a mobile phone. In that case, a battery voltage would be expected to change, depending on whether or not the device is transmitting. Separate output registers can therefore be provided for parameters which depend on whether or not the device is transmitting. For example, measured parameters may include a minimum battery voltage while transmitting, a minimum battery voltage while not transmitting, a maximum battery voltage while transmitting, a maximum battery voltage while not transmitting, an average battery voltage while transmitting, and an average battery voltage while not transmitting.

In addition, the monitoring device in accordance with the invention can be used to monitor a battery voltage during battery charging, the maximum battery

voltage being of most importance. In that case, a charging current can also be measured, and output registers can be provided for parameters such as a maximum current, minimum current, and average current.

The monitoring device of the present invention can further allow threshold values to be set for any of the measured parameter values, and can automatically send a signal to the processor unit whenever any parameter values passes its respective threshold value.

It should be emphasised that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a block schematic diagram of a mobile communications device incorporating a monitoring device in accordance with the invention.

Figure 2 is a flow chart showing operation of the device in accordance with the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Figure 1 is a block schematic diagram of a mobile communications device. The invention is generally applicable to portable radio communication equipment or mobile radio terminals, such as mobile telephones, pagers, communicators, electronic organisers, smartphones, personal digital assistants (PDAs), portable music devices, or the like.

Specifically, Figure 1 shows a mobile phone 10 which, as is conventional, has an antenna 20, connected to transceiver circuits 30, which operate under the control of a CPU 40. The mobile phone 10 is powered by

a battery 50. The battery 50 is shown in Figure 1 as being separate from the phone 10. However, it will be apparent that the invention is equally applicable to monitoring the condition of a battery which is built
5   into, or contained within, a portable electronic device.

In accordance with the invention, the mobile phone 10 includes a monitoring device 60, which is connected to the battery 50 to monitor the voltage supplied
10   thereby and, when the battery 50 is being charged, to monitor the charging current being supplied thereto.

The monitoring device 60 includes an A/D converter 70, which receives analog signals relating to the battery voltage and charging current, and converts them
15   into digital form. A logic unit 72 is connected to the A/D converter 70, to receive therefrom the digital signals. The logic unit 72 is also connected to the transceiver circuitry 30 in this illustrated embodiment of the invention.
20   The logic unit is also connected to supply data to a series of output registers 73-79, as is described in more detail below.

The CPU 40 can access the values stored in the registers 73-79 at any time, retrieving the stored data
25   values on a data bus 80. The logic unit 72 also has a connection to the data bus 80.

Further, the CPU 40, transceiver circuits 30 and logic unit 72 are connected via the internal communications bus 85 of the mobile phone 10, to
30   transmit and receive digital signalling.

Figure 2 is a flow chart describing the operation of the logic unit 72, and in particular describing the measurements which are made, namely the inputs which are taken from the A/D converter 70, and the way in
35   which the registers 73-79 are updated.

The logic unit 72 of the monitoring device 60 receives a new slot, step 100. In this illustrated embodiment of the invention, the 100μs long slots are grouped into sets of 10 slots, allowing some

5   measurements to be made only once in each set of 10 slots, while allowing other measurements at particular modes of operation of the device to be taken more often.

Thus, in step 102, it is determined whether the

10   new slot is the first slot in a set of 10. If so, it is next determined in step 104 whether the phone is in a sleep mode, that is, a mode in which it is switched on, but neither transmitting nor receiving.

If the phone is in a sleep mode, the process

15   passes to step 105, in which it is determined whether or not to make a measurement during that slot. This determination is made on the basis of an adjustable user setting. If the setting is that no measurement is to be made when in the sleep mode, the process returns

20   to the start.

However, if it is determined in step 105 that a measurement should be made, or if it is determined in step 104 that the phone is not in the sleep mode, the procedure passes to step 106, in which the voltage VBAT

25   supplied by the battery is measured.

In step 108, this measured battery voltage can be used to update stored values in one or more of the registers 73-79. Thus, in this case, there is a first register 73 which stores the highest recorded value of

30   the battery voltage $VBAT_{max}$. If the voltage measured in 106 exceeds the value stored in the register 73, it is used to update that stored value.

A second register 74 stores the average voltage which has been supplied by the battery over the

35   preceding second. With one measurement being made

every 1000µs, 1024 successive measurements are added together and divided by 1024, and the resulting average value is stored in the VBAT$_{ave}$ register 74.

5   As well as the maximum voltage supplied by the battery, another parameter which is of importance is the minimum voltage supplied by the battery. However, since the battery voltage will vary, depending on whether or not the device is transmitting at the time, it is advantageous to store two separate minimum

10 values, namely a first minimum value which was recorded while the device was not transmitting, and a second probably lower minimum value which was recorded during a period while the device was transmitting.

In this illustrated preferred embodiment, the

15 logic unit 72 is connected to the transceiver circuitry 30 to receive therefrom a signal which indicates whether the transmitter is active. This signal is provided by devices which operate in some mobile communications systems, such as GSM. However, it is

20 not provided in all systems. For example, this signal is not present in devices which operate in a Wideband Code Division Multiple Access (W-CDMA) system. Thus, in the case of a device which operates only in accordance with a system such as W-CDMA where this

25 signal is not provided, the device of the present invention is unable to provide separate values for the two cases mentioned above. However, a device which operates in a W-CDMA system uses a current which tends to have lower peak values than a device operating in a

30 GSM system. Therefore, the absence of a signal which indicates whether the transmitter is active is relatively unimportant, because it is less important in this case to measure the voltage at a higher rate during transmissions.

35 For a dual mode device, for example operating in

the GSM system and in a system such as W-CDMA which does not provide a signal indicating whether the transmitter is active, two separate output values can be provided. However, an output value stored at a time when the transmitter active signal is not present may for example represent a voltage supplied at a time when the transmitter is active in the W-CDMA mode, in which no such signal is provided.

In step 110, it is determined whether the transmitter active signal TXON is detected. If the transmitter active signal TXON is detected, the process passes to step 112, and the third register 75, storing the minimum battery voltage supplied while the transmitter active signal is supplied, $VBAT_{min}$ @ TXON, is updated. If, on the other hand, the transmitter active signal TXON is not supplied, the process passes to step 114, and the fourth register 76, storing the minimum battery voltage supplied at a time when the transmitter active signal is not provided, $VBAT_{min}$ @ no TXON, is updated, if the currently measured battery voltage falls below that value.

If, at step 102, it is determined that the slot is not the first slot in a set of 10, the process passes to step 116, where it is then determined whether the slot is the last slot in a set of 10. If it is not, the process passes to step 118. As before, it is determined whether the transmitter active signal TXON is being supplied. If it is not, the process passes to step 119, in which it is determined whether or not to make a measurement during that slot. This determination is made on the basis of an adjustable user setting. If the setting is that no measurement is to be made when there is no TXON signal, the process returns to the start and awaits a new slot.

However, if it is determined in step 119 that a

measurement should be made, or if it is determined in step 118 that the transmitter is active, the process passes to step 120, in which the battery voltage is measured.

As previously described, this measured voltage VBAT is compared with the value currently stored in the first register 73 and, if it exceeds that stored value, the value stored in the register is updated, step 122. Similarly, the value is compared with the value stored in the third register 75 and, if it is lower than the stored value, it is used to update the stored value at step 112.

If it is determined at step 116 that the current slot is the last slot of 10, the procedure passes to step 124, where it is determined whether the battery is being charged. If it is not, no measurement is taken and the procedure awaits a new slot. If the battery is being charged, however, the charge current is measured at step 126, and the measured value is used, as appropriate, to update the values stored in the fifth, sixth and seventh registers 77, 78, 79, which store the maximum charging current Imax, the minimum charging current Imin, and the average charging current Iave, at step 128.

These values stored in the register can then be accessed by the CPU 40 as required, for example, only once every second.

This has the advantage, as stated earlier, that the CPU 40 does not have to read a large number of values, in order to obtain the information required about the parameters.

When a stored maximum or minimum value is read from a register by the CPU, the value stored in that register is reset. Thus, the stored value in the register is the maximum or minimum value of the

parameter (as the case may be) since the CPU last read
a stored value.

In the same way as the parameters mentioned above,
it is possible to measure other parameters, such as the
5   temperature of the battery, or of any other component
to which the monitoring device may be connected, and to
store maximum, minimum, and average values of the
temperature or other parameter in registers in the
monitoring device. Again, these parameter values can
10   be accessed by the CPU 40 at any rate considered
appropriate. Since the temperature is a relatively
slowly varying value, it may not be necessary to
monitor the values of the parameters relating to
temperature often.

15   As described in United Kingdom Patent Application
No. 0014840.3, the monitoring device 60 can further
include a function which allows a threshold value to be
set for any or all of the parameters which are measured
by the device. When any parameter reaches its
20   corresponding threshold value, an interrupt signal is
sent to the CPU 40. This means that the CPU may need
to monitor the parameter values less often, because it
will still be informed promptly whenever a threshold
value is reached. This can therefore reduce still
25   further the requirement for communications on the bus.

There is therefore provided a monitoring device
which has the result that communications on the bus are
reduced, and power consumption is reduced. Moreover,
the device is capable of operating in systems with no
30   internal transmit signal, such as W-CDMA.